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Oil, Chemical and Atomic Workers International Union

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September 1, 1983

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Attn: T. O'Bryan
Management Support Division (TS-793)
Office of Toxic Substances
401 M Street, SW
Washington, DC 20460

Dear Sir:

Enclosed is a copy of a report prepared by Rafael Moure, OCAW Industrial Hygienist, for one of our local unions. This report contains unpublished information on o-toluidine and is being sent to you in response to the EPA's letter soliciting this for preliminary risk assessments.

Yours truly,

Dan C. Edwards, Director
Health and Safety Department

pmo

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ENTIRE DOCUMENT

HEALTH AND SAFETY HAZARD EVALUATION

OCAW Local 8-149

January 10, 1983

ESTABLISHMENT:	Morton Chemical 335 McLean Blvd. Paterson, New Jersey 07504
SURVEYED BY:	Rafael Moure, Ph.D., OCAW Industrial Hygienist Geri Kahn, M.D., OCAW Medical Staff Eric Scherzer, OCAW Local 8-149, Health and Safety Committee
SURVEY DATE:	November 30, December 1, 1982
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I. SUMMARY AND RECOMMENDATIONS

On December 1, 1982, a walkaround health and safety inspection was conducted at the Morton Chemical Division, Paterson, New Jersey, Plant of Morton-Norwich Products, Inc.

The OCAW Health and Safety Department and OCAW Local 8-149 conducted the survey which was part of an industrial hygiene and medical Health Hazard Evaluation (HHE) of the facilities. Following the survey, a meeting was held with the company officials and company medical consultants concerning Morton Chemical's medical surveillance program. The principal focus of the discussion was the cancer effects of some dye intermediates and raw materials used at the Paterson plant. This OCAW Health Hazard Evaluation will describe the results of this walkaround and our recommendations for a medical surveillance program.

A. General Recommendations

1. Medical Surveillance (General)

a. Toxicity Information

The company should make available to the Union and to all other medical consultants involved information concerning the specific toxicities of all raw materials and finished products used at the plant which have been the subject of toxicologic testing or the subject of NIOSH's medical surveillance recommendations. The Union would like to examine the details of any of the toxicologic testing that Morton Chemical has had commissioned or plans to commission in the future on the raw materials or finished products utilized at this plant (for example, IBT laboratory tests). If Morton Chemical is not able to find animal toxicological data on a chemical, it should cause such studies to be conducted and shared with OCAW Local 8-149.

b. Medical Records

(1) Medical records should be kept in the Paterson Clinic and available for release to an individual's private physician and as specified under the OSHA Access Standard.

(2) Employees should be notified in writing of any abnormality of physical or laboratory exam and the medically suggested follow up. A copy

of this letter shall automatically be sent to the individual's private physician.

(3) A third copy with employee/patient's identification blanked out should be sent to the company to be kept in a special file to be reviewed once a year by the company and the union for statistical summary.

c. Periodic Reviews

Periodic review of the medical surveillance program should occur within one year after adoption of these additions and thereafter every other year for the purpose of updating tests or procedures as changes in production or scientific information indicate. This review will consist minimally of a written exchange between company and union that no changes are necessary and maximally by a meeting of company, union and medical consultants, if a new change is proposed but not agreeable to both parties.

d. Information on Nature of Surveillance

The company should insure that all employees, new and yearly, will be apprised of the benefits and limitations of the medical surveillance offered, the toxic exposures which require particular attention and the absolute need for follow-up by a personal physician of any abnormalities detected. This should be done verbally and in writing.

e. Information on Non-Routine Exposures

The company should introduce a written procedure to cover instances of chemical spills and sprays in the plant. This should minimally include the supplying of the appropriate MSDS to be carried by an exposed employee at the time of consultation with the examining physician under company contract.

2. Hazard Abatement, General

a. Identification of workers exposed in the past to B-naphtyl-amine, benzidine, o-cresedine, o-tolidine, and other confirmed or suspected bladder carcinogens is necessary. Once workers exposed to these chemicals have been identified, medical evaluation of all of them should follow. Senior workers describe extensive exposures to these substances in the '60s and early '70s.

b. Active steps to further control current exposures to azo dyes; i.e., amino-azo-toluene, azo hydroquinone, as well as o-cresedine and o-tolidine based dyes. Given the carcinogenicity of these products, the union demands that exposure be controlled at the lowest feasible limit.

c. Evaluation of exhaust ventilation system should be done periodically throughout the plant. Comparison of actual capture and mains velocities with designed capture and mains velocities should be done. Appropriate adjustments should be made to assure full effectiveness of the ventilation system.

d. Skin exposures to finished dyes and raw materials should be evaluated, especially with carcinogenic dyes. The company should consider evaluating skin exposure through analysis of urine metabolites using NIOSH methods (see Reference 3). Identification of product dyes by Color Index (CI) number is a must for properly evaluating exposures. OCAW requests a list of products with their CI number.

e. Direct participation of the local union health and safety representative during company industrial hygiene monitoring is a must and should be instituted.

f. A plant-wide comprehensive noise monitoring should be conducted with special emphasis on Buildings 2 and 11.

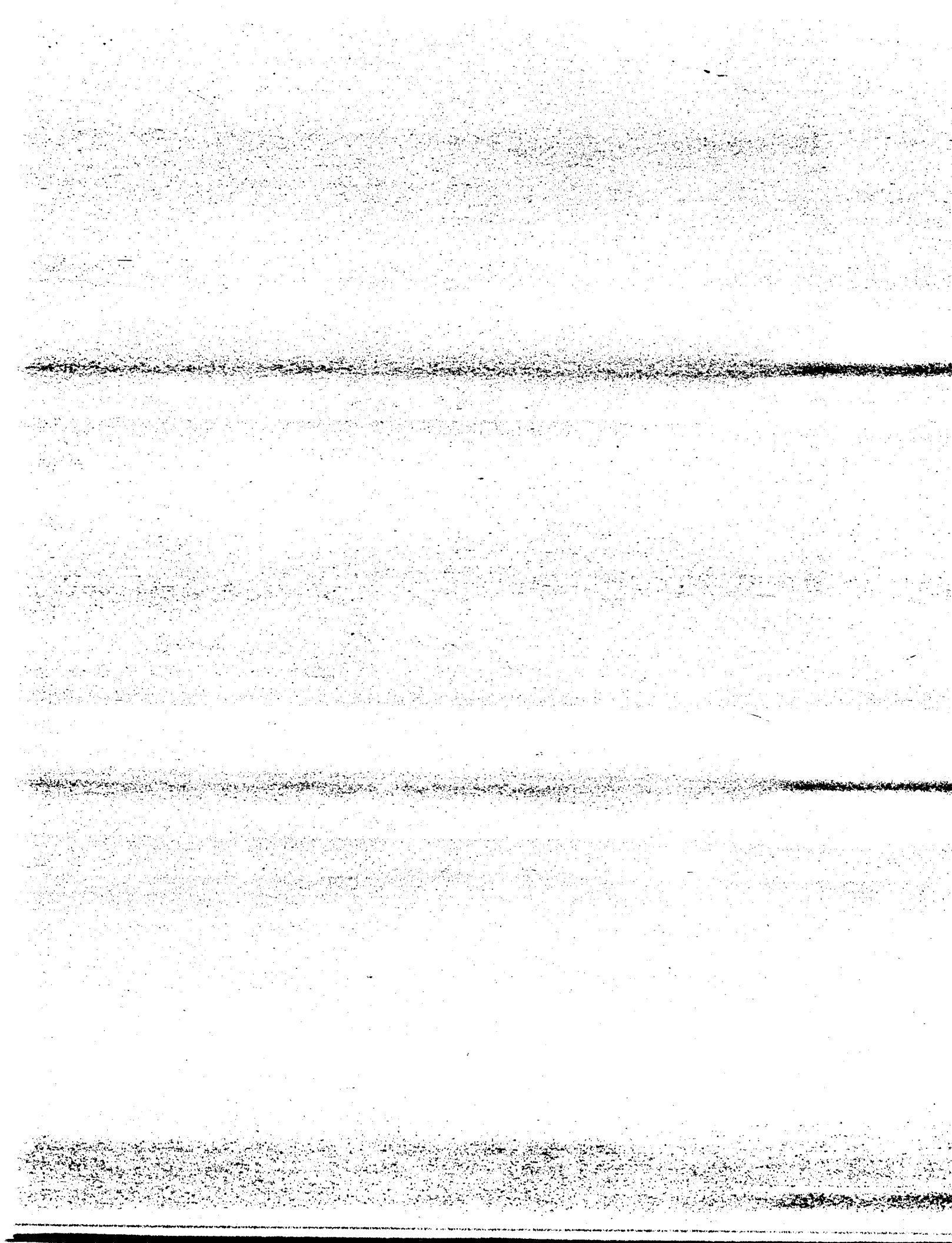
g. The list of carcinogenic dyes identified in Appendix A should be checked with substances handled in the Paterson plant to determine which carcinogens are currently present in the plant. The results of these comparisons in the form of a list should be submitted to OCAW Local 8-149.

B. Specific Recommendations

1. Medical Protocols

a. Medical Protocol (Aromatic Amines)

The following protocol should be utilized for all Morton



Chemical Paterson Plant employees unless it can be documented from a detailed work history that no exposure to aromatic amines would have taken place:

(1) Quarterly urine analysis for microscopic hematuria accompanied by a questionnaire as to symptoms of dysuria, frequency, and urgency should be conducted. Any positive test would trigger an appointment at the Paterson Clinic for a review of possible infective or traumatic etiologies or the necessity of a cytologic exam.

(2) Biannual Urine Cytologies. Collection of urine samples at the plant is highly recommended. It will increase the yield of cells and it will facilitate the collection of a second sample if the first proves to be inadequate. There is a need to establish written protocols for collection, use of appropriate fixative, labeling, and transportation of samples.

(3) If any cytology is positive or suspicious for malignant cells, a repeat cytology should be ordered and if that is positive, the individual will be notified (with copies as designated under general considerations) by letter suggesting he see a urologist of his choice for urologic work-up and treatment if necessary.

(4) The company, in recognition of the role of occupational exposures to the risk of cancer, will agree to pay for the medical tests and consultations necessary as outlined in the protocol (including follow-up by a urologist). Payment shall be covered by any combination of outright reimbursement, contractual arrangement with physician, compensation, insurance

coverage, etc.

(5) Employees having chronic illness due to occupational exposures but able to work, who are advised by their physician to transfer to another department away from exacerbating exposures, shall be permitted to transfer to another department without loss of wage scale or seniority.

(6) The company should make an effort to contact former employees of Morton Chemical, Paterson, by mail who probably had exposure to aromatic amine carcinogens. They will be apprised of the risk and offered participation in the above protocol.

(7) The company should investigate the different tests, their specificity and sensitivity for detecting urinary metabolites of dyes which may indicate actual present level of exposure to carcinogenic or suspected carcinogenic substances; for example, tolidine by method outlined in NIOSH Criteria Document. The company should notify the union of its findings in writing and with participation of the union determine if an appropriate biologic monitoring procedure should be instituted.

(8) The company should disclose to the union the number of workmens' compensation cases filed by employees relevant to urologic problems or cancer since it has owned this plant in 1969.

b. Medical Protocol (Methemoglobin Formers)

(1) Biologic monitoring of methemoglobin levels should be conducted for at least one year. This should include one baseline level (or preshift after two days off) and one end of shift at the end of a work week sample, winter and summer, for a total of three samples per employee. In addition, if a new process occurs where there is exposure to a methemoglobin former, a post shift level should be drawn. Results of this testing should be sent to the Paterson Clinic, the individual involved and a copy with individual identifying information blanked out to the company for a statistical review in one year by the company and union.

(2) Regardless of ongoing yearly methemoglobin testing, any individual exposed during a spill or spray should be immediately examined by a physician for symptomolology. A methemoglobin level shall be drawn as soon as possible and ascertained to be within normal range before the individual is returned to work. This is intended as a minimal, obviously not a maximal, procedure.

2. Specific Hazard Recommendations

a. O-Tolidine (OT). It is our understanding, by statements from Mr. Gavlinski, that the company intends to phase out the use of this suspected bladder carcinogen. In the meantime and only during the time that O-Tolidine is being used, OCAW recommends that the company should consider further

modifications of the OT kettle feeding system in Building 11. Air monitoring demonstrates overexposures from the NIOSH recommendations of 0.02 mg/m^3. Data from 11/19/82 still shows levels of OT six times over the recommended standard. Periodic monitoring should continue to evaluate new control modifications.

b. O-Cresedine. Heating in Building 8 should stop immediately. The "hot rooms" behind Building 7 should be used for heating outside the Building. Since O and P Cresedine are carcinogens (6), exposure to the lowest feasible level should be implemented to avoid exposures to workers transferring dry dye from trays to fiber drums. NOTE: Preheating of 5-chloro-2-amino Toluene should also take place in Building 7, rather than the current practice of heating the chemical in Building 5.

c. A fixed date should be set for installation of new dye grinding equipment in Building 4.

d. A new dye transfer system from trays to fiber drums should also be installed in Building 8. A fixed date for the installation of this new transfer system should be set.

e. Evaluation of the scrubber system in Building 11 should be made. Separation of dyes from water in DC tanks (automate dyes) generates exposure to solvent vapors.

f. Grounding systems at each kettle or drum-out area should be installed to avoid static-generated sparks during liquid transfer.

g. Written procedures for emergencies (i.e., spills and/or leaks) of concentrated sulfuric acid (oleum) should be prepared and posted in Building 5.

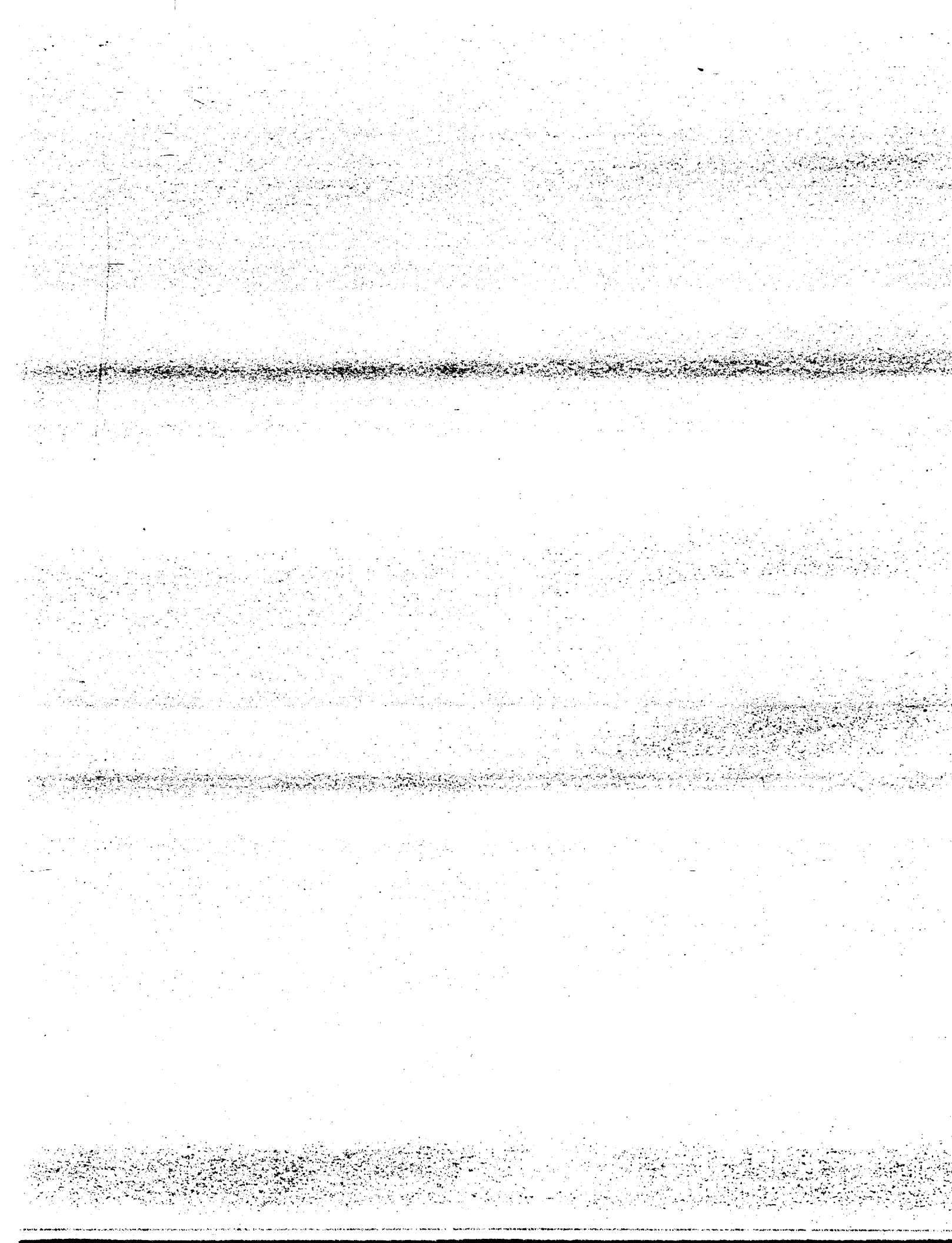
The December 1982 visit to Morton Chemicals is a follow up of three interventions from the OCAW Health and Safety Department, triggered by concerns of members of OCAW Local 8-149.

In 1979, OCAW Industrial Hygienist Rafael Moure inspected the plant because of concern as to exposures to dyes. A second evaluation by Dr. Christine Oliver in 1979 also suggested that the medical surveillance program needed to be directed to the particular exposures existing, specifically the carcinogens and methemoglobin formers. In 1981, Dr. Mark Nelson expressed a similar concern. To get some idea of what monitoring was occurring and the health status of OCAW members, medical records were requested. These were reviewed in April 1982 by Dr. G. Kahn and found to be incomplete due to administrative problems, and reflect an inadequately directed medical surveillance program. Suggestions from Drs. Carnow and Conibear in June 1982 did address some general inadequacies; however, the Union felt several issues concerning a program directed to the carcinogens and methemoglobin formers still existed.

Morton Chemical bought this plant in 1969. In 1976, a medical surveillance program of Celanese Corporation was instituted. This was modified and administered by Paterson Clinic physicians -- unfortunately without knowledge of the specific toxic hazards existing at this plant. Yearly urinary cytologies are in evidence since 1979, performed by Dr. Woo.

Several potent urinary tract carcinogens have been used at this site -- Benzidine for approximately one year in the early '70s; B and A Napthylamine were in use. Currently, we are aware of the use of at least three suspected bladder carcinogens: p-Cresedine, C-Toluidine, and O-Tolidine. Various other aromatic amines have given indefinite results in mutagenicity testing, and other known or suspected carcinogens are also present in the plant, such as anthroquinone derivatives, azo compounds, etc. Many of the aromatic amines used as raw materials and intermediates may cause methemoglobinemia.

This facility produces dyes and pigments. The principal dyes produced are solvent dyes -- solid and liquid. Liquid dyes of two kinds are manufactured -- azo liquid dyes and acid-water soluble dyes. A total of 48 workers are employed in this plant, divided into 38 production and 10 maintenance.



III. OBJECTIVE

The objective of this evaluation is to recommend additions and modifications to the current protocols of medical surveillance instituted by the company. Our recommendations are designed to match specific medical tests to specific exposures to toxic substances in the plant. In addition, suggestions for hazard information and abatement are presented as results of a walkaround industrial hygiene survey.

IV. WALKAROUND OBSERVATIONS

Observations of working conditions are reported building by building.

Building No. 2

Powdered dyes and intermediates are produced in this Building. Exposures to the following contaminants have been reported by the company(1):

1. Azo dye (as Total and Respirable particulate)
2. Methyl Alcohol
3. O-Dichlorobenzene

Exposures to azo dyes range from 0.47 to 1.51 mg/m^3 in one hour samples. Exposures to methyl alcohol range from 79 to 101 ppm measured as 8 hour TWA based on two 2-hour samples of 400 and 316 ppm. Exposures to O-Dichlorobenzene range from 0.36 to 1.67 ppm as 8-hour TWA based on 2-hour samples ranging from 2.5 to 7.2 ppm. A ventilation system is in place. No records of periodic evaluation of the ventilation system were available.

Building No. 4

Finished products are grounded into a fine powder in this Building. Exposures reported by the company (1) to azo dyes are in the range of 0.1 to 2.3 mg/m^3; the highest peak exposure in 1.0 to 18.0 mg/m^3.

The grinding machines are extremely noisy. The company has indicated that new grinding machines are on order and that problems of exposure to dye dust and noise will be substantially alleviated.

Building No. 5

Exposures to p-cresedine, and fuming sulfuric acid mist (oleum) are reported. High exposures to solid p-cresedine were reported before the new process changed its addition mode from solid to slurry. These exposures took place about two years ago. Currently, potential exposures to 5-chloro-2-amino toluene could also take place in this Building.

Building No. 11

The principal product is water based liquid dyes. Exposures to the following chemicals are reported by the company(1):

CHEMICAL	RANGE EXPOSURES	REMARKS
O-Tolidine	0.008-0.26	mg/m^3
		2 samples above PEL
Aniline	0.003-0.72	ppm
Xylene	0.005-0.04	ppm
O-Toluidine	0.004-0.26	ppm
Xylidine	0.003-0.03	ppm

Workers separating ("splitting") solvent dissolved dye from water pointed out high exposures during separation. The scrubbing system does not appear to function properly.

The feeding of O-tolidine to the reaction kettle does not appear to control exposures to the dust all of the time.

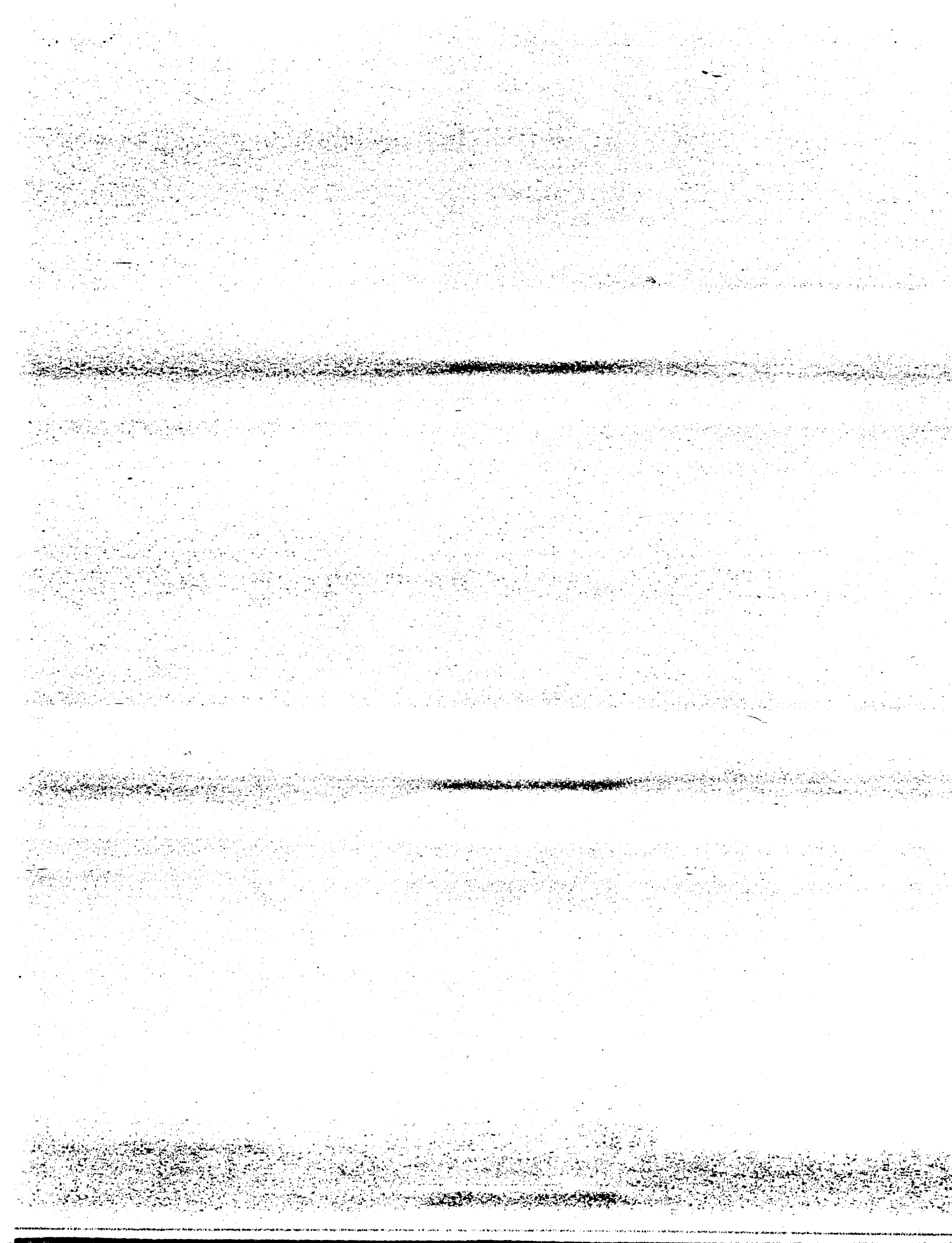
Building No. 8

Dyes are dried in this Building. Dry product is transferred by hand from the driers to fiber drums.

P-cresedine is heated in this Building. There is a special heating cabinet in Building No. 7. It appears unnecessary and dangerous to continue the practice of heating this chemical in Building No. 8.

Building No. 13

The product in this Building is HBN (Hepto-B-Naphtol), an intermediate to dye production in Building 11. Exposure to $ZnCl_2$, heptane and dodecyl amine are reported in this Building.



V. STANDARDS AND RESEARCH

O-TOLIDINE (OT). The NIOSH recommended PEL is still 20 mgm/m^3 (ceiling value)(2). Information on the presence of carcinogenic metabolites of OT in exposed workers was discovered in a recent NIOSH study (3).

AZO DYES. A number of azo dyes have been identified as carcinogens. A list of these dyes (including O-Tolidine Azo Dyes) appear in Tables VIII and X from Reference (4). Azo amino toluene dyes have been also found to be carcinogenic in a recent NIOSH study (5).

O-P-CRESEDINE. (5-methyl-o Anisidine). This aromatic amine has been identified as a carcinogen by NCI research (6).

It will be quite useful to know the Color Index of the dyes used at Morton for accurate identification. The up-to-date research on carcinogenicity of dyes is presented in Appendix A (Reference 4). Dyes used at Morton should be compared with the Tables of this Reference.

Appendix B contains a list of guidelines on the handling of various substances used at Morton Chemical. A copy of the guidelines from Reference (7) for the following substances is included:

Aniline*

Anisidine

Methyl Alcohol

O-Toluidine**

Xylene

Xylidine

*Aniline is considered an animal carcinogen by IARC; See note Aniline, page 5.

**O-Toluidine, OSHA includes this substance on the "candidate list" for regulation as a carcinogen. IARC considers this substance a carcinogen (see Page 4, O-toluidine).

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3. E. Bingham, A. Robbins, NIOSH/OSHA Health Hazard Alert: Benzidine, O-Tolidine, and O-Dianisidine-Based Dyes, Page 6, DHHS, (NIOSH) Publication 81-106, Cincinnati, 1980.

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APPENDIX A

CARCINOGENIC AROMATIC AMINES

Chemical Carcinogens

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ACS Monograph **173**

AMERICAN CHEMICAL SOCIETY
WASHINGTON, D. C. 1976

Chapter

8

Carcinogenic Aromatic Amines and Related Compounds

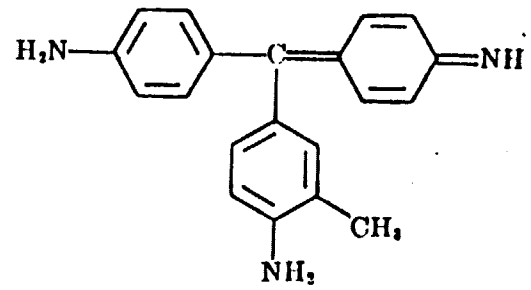
D. B. Clayson[1] and R. C. Garner,[2] Department of Experimental Pathology and Cancer Research, School of Medicine, Leeds LS2 9NL, Yorkshire, England

A CORRELATION BETWEEN aromatic amine exposure and human cancer was reported first by Rehn (*1*) in 1895. He observed that three men, who were employed in making magenta (fuchsin) (1) from commercial aniline at the same factory in Basel, had bladder cancer. A fourth bladder cancer patient was engaged in the same process at another factory. Bladder cancer is sufficiently rare to make a cluster of a few cases noteworthy. Rehn called this condition "aniline cancer," but we now know that this name is inappropriate. This occupational disease was reported subsequently in all countries with an established chemical industry. Experienced medical officers concluded that aniline (2), benzidine (3), 2-naphthylamine (4), and 1-naphthylamine (5) were the probable causative agents (*2*).

An epidemiological survey of bladder cancer in parts of the British chemical industry has greatly clarified this position. Case and his colleagues (*3*) listed all men who had worked in the industry making or using the suspect chemicals between 1921 and 1950. Those who had been employed for less than six months were excluded. The working histories of the more than 4000 remaining names were assembled, and the men were divided into groups that had worked with aniline, benzidine, 2-naphthylamine, 1-naphthylamine, or a mixture of two or more of these chemicals. The incidence of the disease in each group was determined from death certificates, hospital records, reports of coroners' inquests, and by inquiry from the patient or his relatives. Death

[1] Present address: Eppley Institute for Cancer Research, University of Nebraska Medical Center, Omaha, Neb. 68105

[2] Present address: Cancer Research Unit, University of York, Heslington, York, YO1 5DD, England



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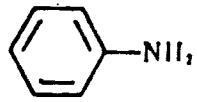

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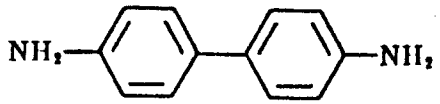

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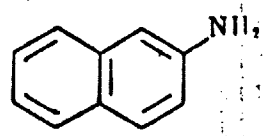

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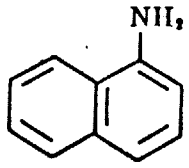

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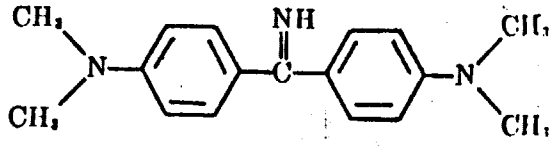

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certificates are an unreliable way to determine the incidence of bladder cancer because many cases have a long prognosis and patients may die of intercurrent disease while their tumor is in remission. In such cases bladder cancer is not shown on the death certificate. As a control for this working population, Case and his colleagues used the entire male working population of England and Wales. The reason for this is referred to below; it meant that statistical comparisons could be made only between the number of death certificates for each group. Fortunately the position was sufficiently clearcut for this not to confuse the situation. It was first shown that aniline induced excess bladder tumors only when used to manufacture auramine (6) and magenta (*4*).

Subsequent work showed that a bladder cancer hazard was demonstrable in the manufacture of these two chemicals but not with aniline in other circumstances. Therefore, it was possible to enlarge the groups of men who had worked with the other suspect chemicals by adding those who had worked with aniline and only one other suspect chemical to the group exposed to the suspect chemical alone. 2-Naphthylamine was the most hazardous material, followed by benzidine and 1-naphthylamine. Even six-months exposure to 2-naphthyl-

a model for amino derivatives of several important ring systems such as 2-FAA, 3-aminobenzofuran, and 3-aminodibenzothiopene and its oxides.

BENZIDINE (4,4′-DIAMINOBIPHENYL) (3). Benzidine is not only carcinogenic to men who make, purify, or use it in the chemical industry (*3, 134*), but is also carcinogenic in certain animal species. The pattern, however, differs from that found with 4-BPA. Bladder tumors were found in the dog (*136*) but only in a proportion of animals after a latent period of seven to nine years and at a time in the life of the dog when spontaneously occurring tumors are common. In rats, subcutaneously injected benzidine induced liver tumors, ear duct carcinomas, and a few adenocarcinomas of the intestine (*126*), while only hepatomas were induced in mice (*136*). In rabbits the toxicity of benzidine prevented an equivalent dose to that in other species being given, and it was not possible to obtain comparable results (*121*).

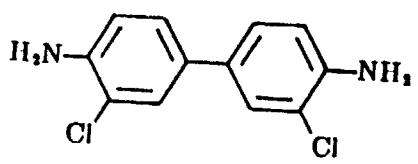
Several derivatives of benzidine, such as *o*-tolidine, 3,3′-dichlorobenzidine (63), and *o*-dianisidine (64), are important as dye intermediates and rubber and plastic compounding ingredients. They are often produced in batches on the benzidine plant and may contribute to the environmental carcinogenic load associated with benzidine in man. Each was investigated experimentally in some depth, especially by Pliss (*137, 138, 139, 140, 141*), who used rats as his test species (Table II) and induced tumors with each compound.

How benzidine is metabolically activated is not known. Clayson (*142*) and Meigs *et al.* (*143*) investigated its metabolism, but there is no evidence to contradict or support the idea that *N*-hydroxylation plays the key role

Table II. Carcinogenicity of

Compound	*Species*	*Route*[a]	*Adequacy*[b]
Benzidine	dog	O	A
	hamster	O	S
	rat	S.C.	A
	mouse	S.C.	S
Diacetylbenzidine	rat	O	S
o,o′-Tolidine	rat	S.C.	A
o,o′-Dianisidine	hamster	O	S
	rat	O	S
3,3′-Dichlorobenzidine	rat	O/S.C.	A
	hamster	O	S
3,3′-Dihydroxybenzidine	rat	O/S.C./ Top	S
3,3′-Benzidinedicarboxylic acid	rat	S.C.	S
	mouse		
2-Methyldiacetylbenzidine	rat	O	S

[a] O, oral; Top, topical; S.C., subcutaneous injection.
[b] A, tested in more than one institute; S, evidence less convincing.



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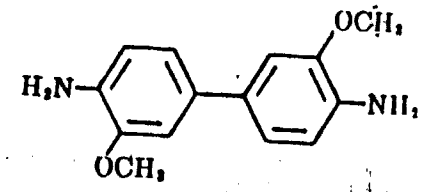

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with these derivatives. The second amino group in the compound makes the synthesis of potential metabolites more difficult.

4,4′-METHYLENEDIANILINE AND ANALOGS. 4,4′-Methylenedianiline (DAPM) (65) and 4,4′-methylene-bis(2-chloroaniline) (DACPM, MOCA) (66) are used extensively in the plastics industry, especially after conversion to the diisocyanate in the manufacture of polyurethane foams and resins. 4,4′-Methylenebis(2-methylaniline) (DAMPM) (*146*) (67) was used experimentally for this purpose but is not manufactured on as large a scale. These chemicals are also used to make dyes such as *p*-rosaniline.

DACPM and DAMPM are carcinogenic when high levels are administered (Table III). DAPM is hepatotoxic and therefore cannot be fed at high levels. The chance contamination of flour which was made into bread led to 84 cases of jaundice and hepatocellular necrosis in the population of an Essex town (*147*). Munn (*148*) reported that DAMPM was far more carcinogenic than

Benzidine and Its Derivatives

Tumors Induced in[a]							
Local	*Bladder*	*Kidney*	*Liver*	*Intestine*	*Ear Duct*	*Breast*	*Other*
−	?+	−	−	−	−	−	−
−	−	−	+	−	−	−	−
−	−	−	+	+	+	−	−
−	−	−	+	−	−	−	−
+	−	−	−	−	+	+	lymphoma, skin
−	?	−	−	−	−	−	forestomach
−	−	−	−	−	?	−	−
−	+	−	−	+	+	+	skin, lymphoma
−	+	−	+	−	−	−	bone
−	−	−	−	−	−	−	none significant
−	−	−	?	−	−	?	? hemopoietic tissue
−	−	−	−	+	+	+	

[a] +, tumors reported; −, tumors not reported; ?, evidence equivocal.

Table V. Carcinogenic Activity of 2-Fluorenamine and Related Compounds

Compound	Species	Route[a]	Adequacy[b]	Tumors Induced in[c]							
				Local	Bladder	Kidney	Liver	Intestine	Ear Duct	Breast	Other
2-Fluorenamine	mouse	V	A	–	?	–	+	–	–	–	–
	rat	V	A	–	–	–	+	+	+	+	lung
2-Fluorenylacetamide	mouse	V	A	–	+	–	+	–	–	+	–
	rat	V	A	–	+	+	+	+	+	+	various
	hamster	V	A	–	–	–	+	–	–	–	–
	guinea pig			–	–	–	–	–	–	–	–
	rabbit	O	A	–	+	–	–	–	–	–	ureter
	cat	O	S	–	–	–	+	–	–	–	lung
	dog	O	S	–	+	–	+	–	–	–	–
	monkey[d]			–	–	–	–	–	–	–	–
	fish		S	–	–	–	+	–	–	–	–
	chicken		S	–	–	+	+	–	–	–	fallopian tube, ovary
9-Hydroxy-2-fluorenylacetamide	rat	O	S	–	–	–	+	–	–	?	–
9-Oxo-2-fluorenylacetamide	rat	O	S	–	–	–	+	?	?	+	–
2-Fluorenyldimethylamine	rat	O	A	–	–	–	+	+	+	+	–
2-Fluorenyldiethylamine	rat	O	S	–	–	–	–	+	–	–	lung
2-Fluorenylmonomethylamine	rat	O	A	–	–	–	+	–	+	+	lung
N-Acetoxyfluorenylacetamide	rat	S.C.	S	+	–	–	–	–	?	–	–
N-Benzoyloxyfluorenylacetamide	rat	S.C.	S	+	–	–	–	–	?	–	–
2-Fluorenyldiacetamide	rat	O	A	–	?	–	+	–	+	+	orbital and Harderian gland tumors
2-Nitrofluorene	rat	O	S	–	–	–	–	?	–	–	?
N-Hydroxy-2-FAA (Fluorenyl-2-acethydroxamic acid)	mouse	V	A	+	+	–	+	–	–	+	–
	rat	V	A	+	–	–	+	+	+	+	–
	hamster	V	A	+	–	–	+	?	–	–	–
	rabbit	V	A	+	+	–	–	?	–	–	–
	guinea pig	V	A	+	–	–	–	+	–	–	–
2-Fluorenylhydroxylamine	rat	S.C.	S	+	–	–	–	–	+	+	–
2-Nitrosofluorene	rat	S.C.	S	+	–	–	–	–	+	–	–
N-Fluorenyl-2-benzamide	rat	I.P.	S	–	–	–	–	–	–	–	–
N-Fluorenyl-2-benzohydroxamic acid	rat	I.P.	S	+	–	–	–	+ (small)	–	+	–
N,2-Fluorenylformamide	rat	O	S	–	–	–	–	–	+	+	–
N-Fluorenyl-2-phthalimic acid	rat	O	S	–	–	–	+	–	–	–	–
N-Fluorenyl-2-benzenesulfonamide	rat	I.P.	S	–	–	–	–	–	–	–	–
N-Hydroxy-*N*-fluorenylbenzene-sulfonamide	rat	I.P.	S	+	–	–	–	–	–	+	? lung
N-2-Fluorenyl(2′-carboxybenz)amide	rat	O	A	–	–	–	+	–	–	–	–
N-2-Fluorenylsuccinamic acid	rat	O	S	–	–	–	+	–	–	–	–
N-2-Fluorenyl-*p*-toluenesulfonamide	rat	O	S	–	–	–	–	–	–	–	–
N-(2-Fluorenyl)-2,2,2-trifluoroacetamide	rat	O	S	–	–	–	+	–	+	+	–

Table V.

Compound	*Species*	*Route*[a]	*Adequacy*[b]
N-3-Glycylaminofluorene	rat	O	S
1-Fluoro-2-FAA	rat	O	S
3-Fluoro-2-FAA	rat	O	S
4-Fluoro-2-FAA	rat	O	S
5-Fluoro-2-FAA	rat	O	S
6-Fluoro-2-FAA	rat	O	S
7-Fluoro-2-FAA	rat	O	A
8-Fluoro-2-FAA	rat	O	S
7-Fluoro-2-*N*-(fluorenyl)acethydroxamic acid	rat	O	S
7-Chloro-2-FAA	rat	O	A
3-Iodo-2-FAA	rat	O	S
7-Iodo-2-FAA	rat	O	S
1-Methoxy-2-FA	rat	O	A
3-Methoxy-2-FA	rat	O	A
1-Methoxy-2-FAA	rat	O	A
3-Methoxy-2-FAA	rat	O	A
7-Methoxy-2-FAA	rat	O	A
2,5-Dinitrofluorene	rat	O	S
2,7-Dinitrofluorene	rat	O	S
2,7-Fluorenyldiamine	rat	O	S
2,5-Fluorenylenebisacetamide	rat	O	S
2,7-Fluorenylbisacetamide	mouse	O	S
	rat	O	A
1-Fluorenylacetamide	rat	I.P.	A
1-Fluorenylacethydroxamic acid	rat	I.P.	S
3-Fluorenylacetamide	rat	I.P.	S
3-Fluorenylacethydroxamic acid	rat	I.P.	S

[a] O, oral; S.C., subcutaneous; I.P., intraperitoneal injection; V, various routes.
[b] A, tested in more than one institute; S, evidence less convincing.
[c] +, tumors reported; −, tumors not reported; ?, evidence equivocal.

carcinogens. The ultimate carcinogen may have to be determined in each tissue which responds to 2-FAA.

Synthetic N-Hydroxy Compounds. Certain substituents on the amino groups of FA are inimical to its enzymic *N*-hydroxylation. Thus, *N*-2-fluorenylbenzamide (*33*) is inactive whereas *N*-2-fluorenylbenzohydroxamic acid induces tumors locally, in the small intestine, and in the breast tissue on intraperitoneal injection (Table V). Similarly, *N*-hydroxy-*N*,2-fluorenylbenzenesulfonamide induces tumors at the injection site in the breast and in the lung, whereas the *N*-2-fluorenylbenzenesulfonamide is not active (*33, 175*). In sub-

Continued

	Tumors Induced in[c]					
Local	*Bladder*	*Kidney*	*Liver*	*Intestine*	*Ear Duct*	*Brea*
−	−	−	+	−	−	−
−	−	−	−	−	+	+
−	−	−	+	−	+	+
−	−	−	−	−	+	+
−	−	−	−	−	+	+
−	−	−	+	+	+	+
−	−	−	+	−	+	+
−	−	−	+	?	+	+
+	−	−	+	+	+	+
−	−	−	?	−	−	−
−	−	−	−	−	+	−
−	−	−	−	−	−	−
−	−	−	+	+	?	−
−	−	−	−	−	−	−
−	−	−	−	?	−	?
−	−	−	−	−	−	−
−	−	−	+	−	+	+
−	−	−	−	−	−	?
−	−	−	−	−	−	+
−	−	−	−	−	−	+
−	−	−	−	−	−	+
−	−	−	+	−	−	−
−	−	−	+	+	+	+
−	−	−	−	−	−	+
−	−	−	−	−	−	+
−	−	−	−	−	−	+
−	−	−	−	−	−	+

[a] In experiments with monkeys, there is doubt whether th
were terminated before tumors could have appeared.

sequent studies it was shown that *N*-hydroxy-*N*,2-fluoreny
was converted to *N*-2-fluorenylhydroxylamine *in vivo* (1

Esterification and Isomeric FAA's. The positional
namely 1-FAA (72) and 3-FAA (73) are carcinogen
mammary glands of female Holtzman rats (*175*).

Recently, Yost and Gutmann (*177*) compared th
2-, 3-, and 4-fluorenylacethydroxamic acids and showed t
3-isomer had approximately equal carcinogenicities and
more carcinogenic than the 4-isomer (the 1-isomer has

Table VII. Carcinogenicity of Aromatic Amines and Their Derivatives with Fused Aromatic Rings: Naphthalene, Anthracene, Phenanthrene etc.

Compound	*Species*	*Route*[a]	*Adequacy*[b]	*Tumors Induced in*[a]							
				Local	*Bladder*	*Kidney*	*Liver*	*Intestine*	*Ear Duct*	*Breast*	*Other*
1-Naphthylamine	mouse	O	S[d]	–	–	–	?	–	–	–	–
	hamster	O	S	–	–	–	–	–	–	–	–
	dog	O	S[d]	–	?	–	–	–	–	–	–
2-Naphthylamine	mouse	O	A	–	–	–	+	–	–	–	–
	rat	O	A	–	–	–	–	–	–	–	–
	hamster	O	S	–	+	–	–	–	–	–	–
	rabbit	O	S	–	–	–	–	–	–	–	–
	cat	O	S	–	–	–	–	–	–	–	–
	dog	O/S.C.	A	–	+	–	–	–	–	–	–
	monkey	O	S	–	+	–	–	–	–	–	–
1-Naphthylacetamide	mouse	O	S	–	–	–	–	–	–	–	–
1-Naphthylhydroxylamine	mouse	Skin	S	+	–	–	–	–	–	–	–
	rat	O	S	+	–	–	–	–	–	–	–
1-Naphthylacethydroxamic acid	rat	I.P./S.C.	S	–	–	–	–	–	–	–	–
2-Naphthylhydroxylamine	mouse	Skin	S	+	–	–	–	–	–	–	–
	rat	I.P.	A	+	–	–	–	–	–	–	–
1-Fluoro-2-naphthylamine	mouse	S.C.	S	–	–	–	–	–	–	–	–
1-Methoxy-2-naphthylamine	mouse	S.C.	S	–	–	–	–	+	–	–	–
3-Methyl-2-naphthylamine	rat	O/S.C.		+	–	?	–	+	–	+	skin
3-Nitro-2-naphthylamine	rat	O	S	–	–	–	–	–	?	–	skin
N,N-Bis(2-chloroethyl)-2-naphthylamine	mouse	I.P.	S	–	–	–	–	–	–	–	lung
1-Anthramine	rat	Top	S	–	–	–	–	–	–	–	–
2-Anthramine	mouse	S.C.	S	–	–	–	+	–	–	–	–
	rat	Top/S.C.	A	+ skin	–	–	–	–	–	+	–
	hamster	Top	A	+	–	–	–	–	–	–	–
9-Anthramine	rat	S.C.	S	–	–	–	–	–	–	–	–
2-Anthranylacetamide	rat	S.C.	S	–	–	–	–	–	–	–	–
1-Phenanthrylamine	mouse	O	S	–	–	–	–	–	–	–	–
	rat	O	S	–	–	–	–	–	–	+[e]	–
2-Phenanthrylamine	mouse	O	S	–	–	–	–	–	–	–	–
	rat	O	S	–	–	–	–	–	–	+[e]	–
3-Phenanthrylamine	mouse	O	S	–	–	–	–	–	–	–	–
	rat	O	S	–	–	–	–	–	–	+[e]	–
9-Phenanthrylamine	mouse	O	S	–	–	–	–	–	–	–	–
	rat	O	S	–	–	–	–	–	–	+[e]	–
1-Phenanthrylacetamide	mouse	I.M.[c]	S	–	–	–	–	–	–	–	–
	rat	O[f]	S	–	–	–	–	–	–	–	–
9,10-Dihydro-2-phenanthramine	rat	O	A	–	–	–	–	+	+	+	–
2-Phenanthrylacetamide	mouse	I.M.	S	–	–	–	–	–	–	–	–
	rat	O	A	–	–	–	–	+	+	+	leukemia
2-Phenanthrylacethydroxamic acid	rat	S.C.	S	+	–	–	–	–	–	+	–

endotheliomas in several tissues, and, from only one report, to bladder tumors. It is also carcinogenic in hamsters, dogs, and possibly in rabbits (Table VIII). It appears to be *N*-hydroxylated *in vivo* because 4,4′-bis(*o*-tolylazo)-2,2′-dimethylazobenzene (87) has been isolated from the liver of

Table VIII. Carcinogenicity of

Compound	*Species*	*Route*[b]	*Adequacy*[c]
4-(Phenylazo)aniline	rat	Top/O	A
	frog	intrarenal	S
4-(Phenylazo)acetanilide	rat	O	A
4-(Phenylazo)diacetanilide	rat	O	S
4-(Phenylazo)-*N*-phenylhydroxylamine	rat	S.C.	S
4-(Phenylazo)-*N*-phenylacethydroxamic acid	rat	O/I.P.	S
4-(Phenylazo)-*o*-anisidine	rat	O/Top	A
4[(*p*-Methoxyphenyl)azo]-*o*-anisidine	rat	O	S
4-(*m*-Tolylazo)aniline	rat	O	S
4-(*m*-Tolylazo)acetanilide	rat	O	S
4(*o*-Tolylazo)-*o*-toluidine	mouse		A
	rat		A
	rabbit		A
	hamster		S
	dog		S
2(*p*-Tolylazo)-*p*-toluidine	mouse	O	S
	rat	O	A
4(*o*-Tolylazo)-*m*-toluidine	rat	O	S
2(*o*-Tolylazo)-*p*-toluidine	mouse	O	S
	rat	O	S
4-(*m*-Tolylazo)-*m*-toluidine	mouse	O	
	rat	O	
4-(*p*-Tolylazo)-*m*-toluidine	mouse	O	
	rat	O	
4-(*p*-Tolylazo)-*o*-toluidine	mouse	O	
	rat	O	
4-(*o*-Tolylazoxy)-*o*-toluidine	rat	O	S
1-[4(*o*-Tolylazo)-*o*-tolylazo]-2-naphthol (Scarlet Red)	Abnormal proliferative lesions only		
4′-Fluoro-*p*-phenylaniline	rat	O	S
1-(Phenylazo)-2-naphthylamine	rat	O/S.C.	A
1-(*o*-Tolylazo)-2-naphthylamine	mouse	O	S
	rat	O/S.C.	A
	dog	O	S

[a] Excluding *N*,*N*-dimethyl derivatives.
[b] O, oral; Top, topical; S.C., subcutaneous injection; I.P., intraperitoneal injection.
[c] A, tested in more than one institute; S, evidence less convincing.

mice treated with 4-(*o*-tolylazo)-*o*-toluidine (*210*). This metabolic activation is confirmed indirectly by the demonstration that 4-(*o*-tolylazo)-*o*-toluidine interacts *in vivo* with DNA, RNA, and protein (*212, 213, 214*).

Five positional isomers of 4-(*o*-tolylazo)-*o*-toluidine were tested for

Derivatives of 4-Phenylazoaniline[a]

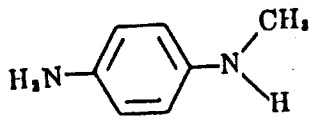
Tumors Induced in[d]							
Local	*Bladder*	*Kidney*	*Liver*	*Intestine*	*Ear Duct*	*Breast*	*Other*
+skin	−	−	−[e]	−	−	−	−
−	−	+	−	−	−	−	−
−	−	−	−	−	−	−	−
−	−	−	−	−	−	−	−
−	−	−	−	−	−	−	−
−	−	−	−	−	−	−	−
+skin (Top)	−	−	+	?	+	−	skin (O)
−	−	−	+	+	?	−	−
−	−	−	−	−	−	−	−
−	−	−	−	−	−	−	−
−	+[f]	−	+	−	−	−	lung, hemangioendothelioma
−	−	−	+	−	−	−	−
−	?	−	−	−	−	−	−
−	+	−	+	−	−	+	−
−	+	−	?	−	−	−	gall bladder
−	−	−	−	−	−	−	−
−	−	−	−	−	−	−	−
−	−	−	−	−	−	−	−
−	−	−	+	−	−	−	−
−	−	−	+	−	−	−	−
−	−	−	−	−	−	−	−
−	−	−	−	−	−	−	−
−	−	−	+	−	−	−	−
−	−	−	−	−	−	−	−
−	−	−	−	−	−	−	−
−	−	−	−	−	−	−	−
			Abnormal proliferative lesions only				
−	−	−	−	−	−	−	−
−	−	−	−	−	−	−	−
−	−	−	−	−	−	−	−
−	−	−	−	−	−	−	−
−	−	−	−	−	−	−	−

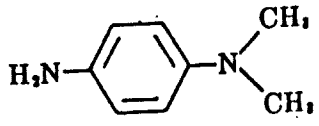
[d] +, tumors reported; −, tumors not reported; ?, evidence equivocal.
[e] One author claims to have induced hepatomas (*see* text).
[f] Possibly on rice diet (*86*).

Table X. Liver Carcinogenicity of

Positive

N,N-Dimethyl-4(4′-benzimidazolylazo)aniline
N,N-Dimethyl-4(6′-benzthiazolylazo)aniline
N,N-Dimethyl-4(7′-benzthiazolylazo)aniline
N,N-Dimethyl-4[4′(2′,6′-dimethylpyridyl-1′-oxide)azo]aniline
N,N-Dimethyl-4(6′-*1H*-indazylazo)aniline
N,N-Dimethyl-4(4′-isoquinolinylazo)aniline
N,N-Dimethyl-4(5′-isoquinolinylazo)aniline
N,N-Dimethyl-4(7′-isoquinolinylazo)aniline
N,N-Dimethyl-4(5′-isoquinolyl-2′-oxide)azoaniline
N,N-Dimethyl-4[4′-(2′,5′-lutidyl)azo]aniline
N,N-Dimethyl-4[4′-(2′,6′-lutidyl-1′-oxide)azo]aniline
N,N-Dimethyl-4[3′,5′-lutidyl-1′-oxide)azo]aniline
N,N-Dimethyl-4[4′(2′-methylpyridyl)azo]aniline
N,N-Dimethyl-4[2′-methylpyridyl-1′-oxide)azo]aniline
N,N-Dimethyl-4[4′-(3′-methylpyridyl-1′-oxide)azo]aniline
N,N-Dimethyl-4[4′(3′-methylpyridyl-1′-oxide)azo]aniline
N,N-Dimethyl-4[4′(2′-methylpyridyl-1′-oxide)azo]*o*-toluidine
N,N-Dimethyl-4[5′(3′-methylquinolyl)azo]aniline
N,N-Dimethyl-4[5′(6′-methylquinolyl)azo]aniline
N,N-Dimethyl-4[5′(7′-methylquinolyl)azo]aniline
N,N-Dimethyl-4[5′(8′-methylquinolyl)azo]aniline
N,N-Dimethyl-4(2′-naphthylazo)aniline
N,N-Dimethyl-4[3′-picolyl-1′-oxide)azo]-*o*-toluidine
N,N-Dimethyl-4[3′-picolyl-1′-oxide)azo]-*m*-toluidine
N,N-Dimethyl-4[4′-pyridyl-1′-oxide)azo]-2,3-xylidine
N,N-Dimethyl-4[(4′-pyridyl-1′-oxide)azo]-2,5-xylidine
N,N-Dimethyl-4[(4′-pyridyl-1′-oxide)azo]-3,5-xylidine
N,N-Dimethyl-4(3′-pyridylazo)aniline
N,N-Dimethyl-4[4′-pyridyl-1′-oxide)azo]aniline
N,N-Dimethyl-4(5′-quinaldylazo)aniline
N,N-Dimethyl-4(3′-quinolylazo)aniline
N,N-Dimethyl-4(4′-quinolylazo)aniline
N,N-Dimethyl-4(5′-quinolylazo)aniline
N,N-Dimethyl-4(6′-quinolylazo)aniline
N,N-Dimethyl-4[(4′-quinolyl-1′-oxide)azo]aniline
N,N-Dimethyl-4[(5′-quinolyl-1′-oxide)azo]aniline
N,N-Dimethyl-4[(6′-quinolyl-1′-oxide)azo]aniline
N,N-Dimethyl-4(5′-quinolylazo)-*m*-toluidine
N,N-Dimethyl-4(2′-quinoxalylazo)aniline
N,N-Dimethyl-4(5′-quinoxalylazo)aniline
N,N-Dimethyl-4(6′-quinoxalylazo)aniline





N,N-Dimethyl-*p*-phenylazoanilines in Rats

Negative

2-Dimethylamino-5(phenylazo)pyridine
N,N-Dimethyl-4(5′-benzimidazolylazo)aniline
N,N-Dimethyl-4(2′-dibenzofuranylazo)aniline
N,N-Dimethyl-4(1′-dibenzothienylazo)aniline
N,N-Dimethyl-4(2′-dibenzothienylazo)aniline
N,N-Dimethyl-4(3′-dibenzothienylazo)aniline
N,N-Dimethyl-4(3-dibenzothienylazo)aniline
N,N-Dimethyl-4(4′-benzthiazylazo)aniline
N,N-Dimethyl-4(5′-benzthiazylazo)aniline
N,N-Dimethyl-4(2-fluorenylazo)aniline
N,N-Dimethyl-4(3′-*1H*-indazylazo)aniline
N,N-Dimethyl-4(4′-*1H*-indazylazo)aniline
N,N-Dimethyl-4(5′-*1H*-indazylazo)aniline
N,N-Dimethyl-4(7′-*1H*-indazylazo)aniline
N,N-Dimethyl-4[2′-(4′-methylpyridyl)azo]aniline
N,N-Dimethyl-4[2′-(6′-methylpyridyl)azo]aniline
N,N-Dimethyl-4-(7′-quinolylazo)aniline
N,N-Dimethyl-4-(8′-quinolylazo)aniline
N,N-Dimethyl-4[2′-quinolyl-1′-oxide)azo]aniline
N,N-Dimethyl-4[3′-quinolyl-1′-oxide)azo]aniline
N,N-Dimethyl-4[7′-quinolyl-1′-oxide)azo]aniline
N,N-Dimethyl-4[8′-quinolyl-1′-oxide)azo]aniline
N,N-Dimethyl-4[2′-(4′-methylpyridyl-1′-oxide)azo]aniline
N,N-Dimethyl-4[2′-(6′-methylpyridyl-1′-oxide)azo]aniline

against DAB carcinogenesis in rat liver. Riboflavin is a component of a flavine adenine dinucleotide which acts as an essential cofactor for the enzyme azo reductase (227). The azo group could be lost also by reduction to a hydrazine and conversion in an acid medium to benzidines or semidines. These could be carcinogenic (*see* page 392). This hypothesis was shown to

APPENDIX B

GUIDELINES FOR CHEMICAL HAZARDS

Aniline
Anisidine
Methyl Alcohol
O-Toluidine
Xylene
Xylidine

NIOSH/OSHA

Occupational Health Guidelines for Chemical Hazards

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Occupational Health Guideline for Aniline*

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $C_6H_5NH_2$
- Synonyms: Aminobenzene; phenylamine; aniline oil
- Appearance and odor: Colorless to brown, oily liquid with a weak amine odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for aniline is 5 parts of aniline per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 19 milligrams of aniline per cubic meter of air (mg/m^3). The American Conference of Governmental Industrial Hygienists has recommended for aniline a Threshold Limit Value of 2 ppm with a skin notation.

HEALTH HAZARD INFORMATION

- Routes of exposure

Aniline can affect the body if it is inhaled, comes in contact with the eyes or skin, or is swallowed. It is readily absorbed through the skin, either as a liquid or vapor. Even a small amount absorbed from the clothes or shoes may cause toxic symptoms.

- Effects of overexposure

1. Short-term Exposure: Aniline affects the ability of the blood to carry oxygen. Moderate exposure to aniline may cause only a bluish discoloration of the skin. As oxygen deficiency increases, the blue discoloration may be associated with headache, weakness, irritability, drowsiness, shortness of breath, and unconsciousness. If treatment is not given promptly, death can occur. Aniline is irritating to the eyes and may cause eye damage. The onset of symptoms may be delayed.

2. Long-term Exposure: Repeated skin or respiratory exposure to aniline may cause headache, irritability, insomnia, dizziness, decreased appetite, paleness, and anemia.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to aniline.

- Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to aniline at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the blood, cardiovascular system, liver, and kidneys should be stressed.

—A complete blood count: Aniline has been shown to cause methemoglobinemia. A complete blood count should be performed including a red cell count, a white cell count, a differential count of a stained smear, as well as hemoglobin and hematocrit.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

- Summary of toxicology

Aniline absorption, whether from inhalation of the vapor or skin absorption of the liquid, causes anoxia due to the formation of methemoglobin. Rats exposed to 5 ppm of vapor daily for 6 months showed no effects other than slight methemoglobinemia. Human exposure to vapor concentrations of 7 ppm has been observed to cause slight symptoms. Rapid absorption through the intact skin is frequently the main route of entry; a small amount absorbed from contaminated clothing or shoes may cause intoxication, characterized by cyanosis. Following skin absorption, the onset of symptoms may be delayed for up to 4 hours. Headache is commonly the first symptom and may become quite intense as the

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severity of methemoglobinemia progresses. Cyanosis develops early in the course of intoxication, first in the lips, nose, and ear lobes, and is usually recognized by fellow workers. Cyanosis occurs when the methemoglobin concentration is 15% or more. The individual usually feels well, has no complaints, and may insist that nothing is wrong, although cyanosis is evident to observers, until the methemoglobin concentration approaches approximately 40%. At methemoglobin concentrations of over 40%, there usually is weakness and dizziness; up to 70% concentration, there may be ataxia, dyspnea on mild exertion, and tachycardia. The development of intravascular hemolysis and anemia due to aniline-induced methemoglobinemia has been postulated, but neither is often observed in industrial practice despite careful and prolonged study of numerous cases. Occasional deaths from asphyxiation caused by severe aniline intoxication are said to have occurred. Liquid aniline is mildly irritating to the eyes and may cause corneal damage.

CHEMICAL AND PHYSICAL PROPERTIES

- Physical data
  1. Molecular weight: 93.1
  2. Boiling point (760 mm Hg): 184 C (364 F)
  3. Specific gravity (water = 1): 1.022
  4. Vapor density (air = 1 at boiling point of aniline): 3.22
  5. Melting point: −6.2 C (21 F)
  6. Vapor pressure at 20 C (68 F): 0.6 mm Hg
  7. Solubility in water, g/100 g water at 20 C (68 F): 3.5
  8. Evaporation rate (butyl acetate = 1): Less than 1
- Reactivity
  1. Conditions contributing to instability: Heat
  2. Incompatibilities: Contact of liquid aniline with strong acids will cause violent spattering. Contact with strong oxidizers may cause fires and explosions.
  3. Hazardous decomposition products: Toxic gases and vapors (such as oxides of nitrogen and carbon monoxide) may be released in a fire involving aniline.
  4. Special precautions: Liquid aniline will attack some forms of plastics, rubber, and coatings.
- Flammability
  1. Flash point: 70 C (158 F) (closed cup)
  2. Autoignition temperature: 615 C (1139 F)
  3. Flammable limits in air, % by volume: Lower: 1.3; Upper: Data not available
  4. Extinguishant: Carbon dioxide, alcohol foam, dry chemical
- Warning properties
  1. Odor Threshold: May reports an odor threshold for aniline of 7 ppm; the MCA reports that "the odor of aniline can usually be detected without difficulty in concentrations of 0.5 ppm," and Thienes and Haley report an odor threshold of 1 ppm.
  2. Eye Irritation Level: The MCA reports that "aniline is mildly irritating to the eyes and may cause corneal damage," but no quantitative information is given. Grant reports that "many years ago workers chronically exposed to crude aniline vapors had irritation of the eyes, photophobia, and impairment of vision," but he suggests that the disturbances of the cornea and conjunctiva which were observed might have been caused by "quinonelike oxidation products." Based upon the information reported by MCA, aniline is treated as an eye irritant for the purposes of this guideline.
  3. Evaluation of Warning Properties: Since the odor threshold ranges from a concentration well below the permissible exposure limit to a concentration only slightly greater than the permissible exposure limit, aniline is treated as a material with good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- General

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- Method

Sampling and analyses may be performed by collection of aniline in an adsorption tube containing silica gel, followed by desorption with ethanol and gas chromatographic analysis. An analytical method for aniline is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent skin contact with liquid aniline, where contact may occur.

• Clothing contaminated with aniline should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of aniline from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the aniline, the person performing the operation should be informed of aniline's hazardous properties.

• Where exposure of an employee's body to liquid aniline may occur, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

• Non-impervious clothing which becomes contaminated with aniline should be removed immediately and not reworn until the aniline is removed from the clothing.

• Employees should be provided with and required to use splash-proof safety goggles where liquid aniline may contact the eyes.

SANITATION

• Skin that becomes contaminated with aniline should be immediately washed or showered with soap or mild detergent and water to remove any aniline.

• Eating and smoking should not be permitted in areas where liquid aniline is handled, processed, or stored.

• Employees who handle liquid aniline should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to aniline may occur and control methods which may be effective in each case:

Operation	Controls
Use in chemical synthesis and intermediates for rubber processing; use in production of MDI and PMPPI in manufacture of rigid polyurethanes; use in synthesis of dyestuffs and intermediates for dyestuffs	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of pharmaceuticals and intermediates for pharmaceuticals; synthesis of hydroquinone for photographic processing; synthesis of intermediates for agricultural chemicals	Process enclosure; local exhaust ventilation; personal protective equipment
Use in manufacture of inks, for cloth marking inks, indelible inks, and lithographic and other printing inks	Process enclosure; local exhaust ventilation; personal protective equipment
Use in production of PACM monomer in nylon fiber manufacture; use in synthesis of resins	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of intermediates for artificial sweetening agents	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of catalysts and stabilizers for hydrogen peroxide and cellulose; use in synthesis of corrosion inhibitors	Process enclosure; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If aniline gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If aniline gets on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If

aniline soaks through the clothing, remove the clothing promptly and wash the skin using soap or mild detergent and water. Get medical attention promptly.

• Breathing

If a person breathes in large amounts of aniline, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Swallowing

When aniline has been swallowed, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

• Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If aniline is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill or leak.
2. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected and atomized in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device.

• Waste disposal methods:

Aniline may be disposed of:

1. By absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.
2. By atomizing in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device.

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• *Survey of Compounds Which Have Been Tested for Carcinogenic Activity*, U.S. Public Health Service Publication No. 149, Original, Supplements 1 and 2, 1961-1967, 1968-1969, and 1970-1971.
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The International Agency for Research on Cancer (IARC) has evaluated the data on this chemical and has concluded that it causes cancer. See *IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man*, Volumes 4 and 7, 1974.

RESPIRATORY PROTECTION FOR ANILINE

Condition	Minimum Respiratory Protection* Required Above 5 ppm
Vapor Concentration	
100 ppm or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s). A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 100 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Occupational Health Guideline for Anisidine (o,p-Isomers)

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $NH_2C_6H_4OCH_3$
- Synonyms: o-Methoxyaniline; p-methoxyaniline
- Appearance and odor: Ortho: Cololorless to pink liquid with a characteristic amine odor; Para: Light red-brown solid with a characteristic amine odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for anisidine is 0.5 milligram of anisidine per cubic meter of air (mg/m^3) averaged over an eight-hour work shift.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Anisidine can affect the body if it is inhaled, comes in contact with the eyes or skin, or is swallowed. It may enter the body through the skin.

- **Effects of overexposure**

Exposure to anisidine may affect the ability of the blood to carry oxygen. The earliest effect may be a bluish color of the skin, especially the lips. If the lack of oxygen becomes severe, a person may have drowsiness, headache, nausea, and vomiting. If oxygen lack is very severe, it may cause unconsciousness and even death.

- **Reporting Signs and Symptoms:**

A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to anisidine.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to anisidine at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the blood, kidneys, liver, and cardiovascular system should be stressed.

—A complete blood count: Anisidine has been shown to cause methemoglobinemia and the formation of erythrocytic inclusion bodies. A complete blood count should be performed including a red cell count, a white cell count, a differential count of a stained smear, as well as hemoglobin and hematocrit.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

- **Summary of toxicology**

The absorption of the ortho or para isomer of anisidine, whether from inhalation of the vapor or dust or from skin absorption, causes anoxia due to the formation of methemoblobin. The peroral LD50 in rats was 1.4 g/kg. Mice repeatedly exposed to concentrations of 10 to 30 mg/m^3 for 2 hours daily showed a decrease in the excitability of nerves at the end of 1 month of exposure; after 12 months of exposure there was anemia and reticulocytosis. Workers exposed to a concentration of 1.9 mg/m3 for 3-½ hours per day for 6 months did not develop anemia or specific signs of intoxication; there were some cases of headache and vertigo, which may have been related to the observation of increased methemoglobin and sulfhemoglobin; the presence of erythrocytic inclusions, or Heinz bodies, was observed.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 123

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or when they fail and need to
tors may also be used for
entry into tanks or closed
y situations. If the use of
e only respirators permitted
pproved by the Mine Safety
(formerly Mining Enforce-
tration) or by the National
Safety and Health.
selection, a complete respira-
should be instituted which
, maintenance, inspection,

CTIVE EQUIPMENT

ovided with and required to
oves, face shields (eight-inch
ropriate protective clothing
contact with solid or liquid
ining anisidine, where skin

ay have become contaminat-
isidine or liquids containing
d change into uncontaminat-
he work premises.
with anisidine should be
s for storage until it can be
n is made for the removal of
ng. If the clothing is to be
aned to remove the anisidine,
peration should be informed
perties.
employee's body to solid or
s containing anisidine may
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mediate work area for emer-

g which becomes contami-
ld be removed immediately
nisidine is removed from the

ovided with and required to
safety goggles where solid or
s containing anisidine may

ontaminated with anisidine
shed or showered with soap
ter to remove any anisidine.
uld not be permitted in areas
isidine or liquids containing
essed, or stored.
: solid or liquid anisidine or
ne should wash their hands
mild detergent and water
using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to anisidine may occur and control methods which may be effective in each case:

Operation	Controls
Use in manufacture of azo or triphenylmethane dyes and intermediates; use in preparation of organic compounds; in synthesis of guaicol	General dilution ventilation; personal protective equipment
Use in synthesis of hair dyes; as corrosion inhibitors for steel storage; as an antioxidant for some polymercaptan resins; and as a dyeing assist	General dilution ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If anisidine gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If solid or liquid anisidine or liquids containing anisidine get on the skin, immediately wash the contaminated skin using soap or mild detergent and water. If solid or liquid anisidine or liquids containing anisidine penetrate through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. Get medical attention immediately.

• **Breathing**

If a person breathes in large amounts of anisidine, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When solid or liquid anisidine or liquids containing anisidine have been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• **Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.**

• **If anisidine is spilled or leaked, the following steps should be taken:**

1. **Ventilate area of spill or leak.**
2. Collect spilled material in the most convenient and safe manner for reclamation or for disposal in a secured sanitary landfill. Liquids containing anisidine should be absorbed in vermiculite, dry sand, earth, or a similar material. Large quantities may be reclaimed; however, if this is not practical, dissolve in a flammable solvent (such as alcohol) and atomize in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device.

• **Waste disposal method:**

Anisidine may be disposed of in a secured sanitary landfill.

REFERENCES

• American Conference of Governmental Industrial Hygienists: "Anisidine," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.

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• Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.

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RESPIRATORY PROTECTION FOR ANISIDINE (o,p-ISOMERS)

Condition	Minimum Respiratory Protection* Required Above 0.5 mg/m³
Particulate or Vapor Concentration	
2.5 mg/m³ or less	Any dust and mist respirator, except single-use.
5 mg/m³ or less	Any dust and mist respirator, except single-use or quarter-mask respirator. Any supplied-air respirator. Any self-contained breathing apparatus.
25 mg/m³ or less	Any high efficiency particulate filter respirator with a full facepiece. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
50 mg/m³ or less	A powered air-purifying respirator with a high efficiency particulate filter. A Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode.
Greater than 50 mg/m³ or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Occupational Health Guideline for Methyl Alcohol

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: CH_3OH
- Synonyms: Methanol; wood alcohol; Columbian spirits; carbinol
- Appearance and odor: Colorless liquid with a characteristic, pungent odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for methyl alcohol is 200 parts of methyl alcohol per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 260 milligrams of methyl alcohol per cubic meter of air (mg/m^3). NIOSH has recommended that the permissible exposure limit be changed to 200 ppm averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling of 800 ppm averaged over a 15-minute period. The NIOSH Criteria Document for Methyl Alcohol should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Methyl alcohol can affect the body if it is swallowed, is inhaled, or comes in contact with the skin or eyes.

- **Effects of overexposure**

1. Short-term Exposure: Swallowing methyl alcohol or breathing very high concentrations of methyl alcohol may produce headache, weakness, drowsiness, lightheadedness, nausea, vomiting, drunkenness, and irritation of the eyes, blurred vision, blindness, and death. A person may get better and then worse again up to 30 hours later.

2. Long-term Exposure: Prolonged exposure to higher concentrations of methyl alcohol may result in headaches, burning of the eyes, dizziness, sleep problems, digestive disturbances, and failure of vision. Repeated or prolonged skin exposure may cause skin irritation.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to methyl alcohol.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to methyl alcohol at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the employee at increased risk, and to establish a baseline for future health monitoring. Examination of the skin, liver, kidneys, and eyes should be stressed.

—Skin disease: Methyl alcohol is a defatting agent and can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be susceptible to the effects of this agent.

—Liver function tests: Methyl alcohol may cause liver damage. A profile of liver function should be obtained by utilizing a medically acceptable array of biochemical tests.

—Kidney disease: Although methyl alcohol has not been proven to be kidney toxin in humans, the importance of this organ in the elimination of toxic substances justifies special consideration in those with impaired renal function.

—Eye disease: Because methyl alcohol may cause optic atrophy and blindness, those with pre-existing eye diseases may be at increased risk from exposure.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis. In addition, anyone developing the above-listed conditions or who has been splashed in the eyes with,

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Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

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has ingested, or otherwise has been exposed to methyl alcohol should be placed under medical surveillance.

• Summary of toxicology

Ingestion of methyl alcohol is a well-known cause of optic neuropathy and may be lethal. Severe acidosis may result from ingestion or high exposures. Animals exposed to vapor concentrations above 8000 to 10,000 ppm show narcotic effects progressing from lethargy, to ataxia, to prostration and death in a state of profound acidosis due in part to the metabolic formation of formaldehyde and formic acid. Occupational exposure to high concentrations of methyl alcohol vapor has been reported to cause death or blindness, usually from working in a confined space. A woman died after exposure for 12 hours to vapor concentrations calculated at 4000 to 13,000 ppm. Chronic poisoning manifested by marked diminution of vision and enlargement of the liver has been reported in a workman exposed at levels of 1200 to 8000 ppm for a period of 4 years. Direct skin contact with methy alcohol may cause dermatitis, erythema, and scaling.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 32
2. Boiling point (760 mm Hg): 64.5 C (148 F)
3. Specific gravity (water = 1): 0.8
4. Vapor density (air = 1 at boiling point of methyl alcohol): 1.1
5. Melting point: −98 C (-144 F)
6. Vapor pressure at 20 C (68 F): 97 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Miscible in all proportions
8. Evaporation rate (butyl acetate = 1): 5.9

• Reactivity

1. Conditions contributing to instability: Heat
2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide and formaldehyde) may be released in a fire involving methyl alcohol.
4. Special precautions: Methyl alcohol will attack some forms of plastics, rubber, and coatings. It may also react with metallic aluminum at high temperatures.

• Flammability

1. Flash point: 11 C (52 F) (closed cup)
2. Autoignition temperature: 385 C (725 F)
3. Flammable limits in air, % by volume: Lower: 6.7; Upper: 36
4. Extinguishant: Dry chemical, alcohol foam, carbon dioxide

• Warning properties

1. Odor Threshold: May and Summer report that the odor threshold of methyl alcohol (methanol) is 5900 ppm. The AIHA *Hygienic Guide* states that the odor is faint at 2000 ppm.
2. Eye Irritation Level: The *Hygienic Guide* states that irritation occurs only at high concentrations. Grant states that "external contact of methanol with the eye has been alleged to have caused corneal opacities, but this must be far from the rule . . . . By exposure of cats to methanol vapors an attempt has been made to induce vacuoles in the corneal epithelium similar to those produced by other solvents, but this has been unsuccessful."

Browning reports that concentrations ranging from 7500 ppm to 69,000 ppm irritate mucous membranes.

3. Evaluation of Warning Properties: Methyl alcohol (methanol) has poor warning properties.

MONITORING AND MEASUREMENT PROCEDURES

• Eight-Hour Exposure Evaluation

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• Ceiling Evaluation

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of methyl alcohol. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• Method

Sampling and analyses may be performed by collection of methyl alcohol in an adsorption tube containing silica gel, followed by desorption with water, and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure methyl alcohol may be used. An analytical method for methyl alcohol is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 2, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00260-6).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the

process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid methyl alcohol.
- Clothing wet with liquid methyl alcohol should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of methyl alcohol from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the methyl alcohol, the person performing the operation should be informed of methyl alcohol's hazardous properties.
- Any clothing which becomes wet with liquid methyl alcohol should be removed immediately and not reworn until the methyl alcohol is removed from the clothing.
- Employees should be provided with and required to use splash-proof safety goggles where liquid methyl alcohol may contact the eyes.

SANITATION

- Skin that becomes wet with liquid methyl alcohol should be promptly washed or showered to remove any methyl alcohol.
- Eating and smoking should not be permitted in areas where liquid methyl alcohol is handled, processed, or stored.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to methyl alcohol may occur and control methods which may be effective in each case:

Operation	Controls
Liberation during application of surface coatings such as shellac, wood dyes, nitrocellulose lacquers, water-proofing formulations, and phenolic resins	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Use as a solvent for rotogravure inks, aniline dyes, and duplicator fluids	General dilution ventilation
Liberation during manual application of methanol as a cleaner for coated surfaces, leather, gloves, and metal and resins surfaces prior to further treatment	General dilution ventilation; personal protective equipment
Liberation during manufacture of formaldehyde by oxidation or dehydrogenation	Local exhaust ventilation; general dilution ventilation
Use in plastics industry to produce plasticizers, softening agents, and acrylic resins	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Liberation during use as an intermediate in the preparation of methacrylates, methyl chlorides, methyl ethers, dimethyl sulfate, methyl formate, and methyl bromide	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Liberation during application as an extractant in industrial chemical processes such as refinery gasoline and oils and purifying pharmaceuticals such as steroids and hormones	Local exhaust ventilation; general dilution ventilation
Use as a solvent in rubber industry	Local exhaust ventilation; general dilution ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If methyl alcohol gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If methyl alcohol gets on the skin, promptly flush the contaminated skin with water. If methyl alcohol soaks through the clothing, remove the clothing immediately and flush the skin with water. If there is skin irritation, get medical attention.

• Breathing

If a person breathes in large amounts of methyl alcohol, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Swallowing

When methyl alcohol has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

• Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If methyl alcohol is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected and atomized in a suitable combustion chamber. Methyl alcohol should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion.

• Waste disposal methods:

Methyl alcohol may be disposed of:

1. By absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.
2. By atomizing in a suitable combustion chamber.

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RESPIRATORY PROTECTION FOR METHYL ALCOHOL

Condition	Minimum Respiratory Protection* Required Above 200 ppm
Vapor Concentration	
2000 ppm or less	Any supplied-air respirator. Any self-contained breathing apparatus.
10,000 ppm or less	Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
25,000 ppm or less	A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.
Greater than 25,000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.